New Retention System Using Branched Polymer

Dong-Jin Son* and Bong-Yong Kim†

*Student of doctoral course, †Professor
Department of Wood science and Technology, Kyungpook National University, Daegu 702-701, Korea
Corresponding Author's E-mail (djson2000@yahoo.co.kr)

ABSTRACT

The purpose of this study was to confirm multiple retention system of C-PAM, A-PAM and Inorganic micro particles vs. traditional micro particle system and dual polymer system by measuring retention, drainage and formation using RDA HSF and Techpap 2D -F Sensor. The benefits of dual polymer system were easy to use, low chemical consumption and good retention property but defect was worse drainage property than inorganic microparticle systems. On the other hand, Inorganic microparticle system had benefit of good drainage effect but defects were difficult to use, high chemical consumption. Therefore, we tried to find optimal morphology of polyacrylamide and applied to multiple retention system of C-PAM, A-PAM and inorganic microparticles to compensate defects of both of retention systems. As a result, we found the performance of branched C-PAM, branched A-PAM and inorganic micro particle triple system was more appropriate than traditional inorganic mircoparticle systems or dual polymer systems by comparing retention, drainage and formation.

1. INTRODUCTION

Retention aids to be applied to paper industry have been classified very important components to influence not only wet-end process improvement but also paper quality because they induce flocculation of pulp and fillers. Quality factors of retention aids are retention, drainage and paper formation which are very sensitively related to molecular weight, morphology and dosage of the polymer and time and shear of the reaction. Therefore, keeping of the balance among them are very important. Recent most common retention system was a synthetic organic polymer with inorganic micro-particle system. As a synthetic organic polymer, cationic polyacrylamide was commonly applied and as a inorganic micro-particle, colloidal silica and swollen bentonite were mainly applied. Compare to single polymer system of polyacrylamide and dual polymer system of coagulant of polyamine or p-DADMAC and polyacrylamide, these inorganic microparticle system have good benefits of the better retention and drainage and less negative influence to the formation. The point of inorganic microparticle system is that first of all, flocs of pulp and filler are formed by the addition of cationic polyacrylamide and then disperse to small tiny flocs by high shear and finally uniform flocs are formed by reunion with inorganic microparticles. These uniform flocs of the pulp and filler give positive effect to retention, drainage and formation. The weak points of these inorganic microparticle systems were that higher dosage of bentonite and silica compare to organic polymer because of their low anionicities. And especially, it was very difficult to prepare the bentonite for dosing because bentonite was needed high shear and reaction time for swelling. Therefore, there have been some trial to make up for weak point of inorganic microparticle system to adjust branch degree of the organic synthetic polymers. The purpose of this study was to select optimal morphological conditions of the cationic and anionic polyacrylamide and then find optimal composition of the cationic polyacrylamide, inorganic microparticle and anionic polyacrylamide triple retention system.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Pulps and fillers

85% of LBKP mixed with 15% ground-calcium carbonate (GCC) and then applied to retention, drainage and formation test. The pulp of LBKP with GCC stands for typical print paper grade simulation.

2.1.2. Inverse emulsion type polyacrylamide

Cationic water in oil emulsions were polymerized by procedure of emulsification, polymerization and inversing treatment. To begin with emulsification, we added water, acrylamide, dimethylaminoethyl acrylate methylchloride quaternary salt monomer, hydrocarbon oil and surfactants to the reactor and gave high shear to emulsify. We adjusted branch degree to change concentration of branching monomer and then we polymerized with dropping of redox catalyst. Finally we added hydrophilic inversing surfactants to the reactor to give a good solubility of emulsion in the water. Anionic water in oil emulsions were polymerized by similar procedure to above but applied different monomer like Na-acrylate instead of dimethylaminoethyl acrylate methylchloride quaternary salt monomer

2.1.3. Inorganic microparticle

In case of bentonite, after 1 hour of high shear under 2,000 rpm and additional 4 hour of retention time was required to make bentonite swollen. In case of silica, we used commercial precipitated silica dispersed liquid.

2.2 Methods

2.2.1 Estimation of branch degree

A-PAM and C-PAM were diluted at various consistency with distilled water using magnetic stirrer during 30 minutes. And then, comparison of physical and chemical characteristics of viscosity profile, and charge titration phenomena were estimated to determine morphological condition of C-PAM and A-PAM.

2.2.2 Pre treatment of pulps

LBKP was disintegrated by the Tappi standard disintegrator at the 20℃ water temperature. Conditions of disintegration were as belows.

Concentration of the pulp was 3%, and speed of agitator was 3000 rpm at 5,000 revolution during 30 minutes.

After disintegration, beating was performed at the condition of 0.3% consistency during 30 minutes using niagara beater. Then, LBKP stock was prepared by 400 ±10 ml CSF.

After disintegrating and beating, stock was mixed with GCC at the rate of pulp 85% and GCC filler 15% to be final consistency to 0.18%.

2.2.3 Retention test

RDA-HSF paper machine condition was as followings. Pressure at the tank and sub-tank were 200 mmHg, and Basis weight was 60 g/m2and retention was measured with turbidity of the white water using Lamotte 2020 turbidimeter. At this time, unit of the measurement was NTU and lower value of the data was better retention effect.

2.2.4 Drainage test

RDA-HSF paper machine condition was the same as retention test. We evaluated drainage rate from comparing vacuum profile curves at the point of paper forming. At this time, steeper slope of the curve was better drainage rate.

2.2.5 Paper forming and formation test

RDA-HSF paper machine condition was the same as retention test. Wet paper was dried using drum dryer which was adjusted temperature at the 130℃. After that, we evaluated paper formation using 2D-F sensor of Techpap France. Unit of the measurement was LT and lower value was better formation.

3. RESULT AND CONSIDERATION

3.1. Estimation of branch degree of PAM

3.1.1 Branch degree by viscosity profile

Fig.1 and Fig.2 shows profiles of PAM between viscosity and consistency. In case of linear PAM, viscosity changed slowly by increase of consistency but, structured PAM resulted reversely. This phenomena could be applied to estimate morphological condition of PAM.

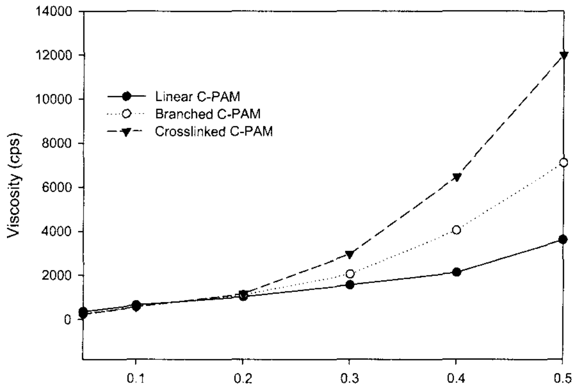

Fig. 1 Viscosity profile of C-PAM

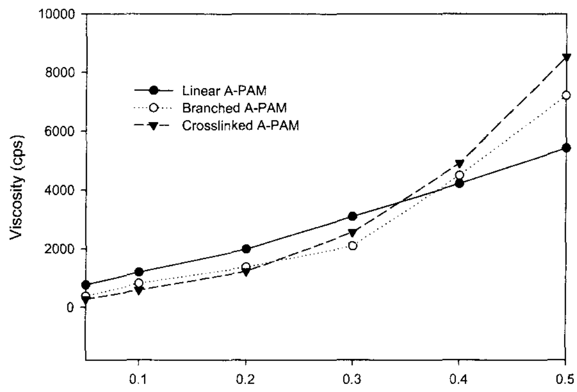

Fig. 2 Viscosity profile of A-PAM

3.1.2 Branch degree by streaming current

Fig.3 and Fig.4 shows charge titration curves of C-PAM and A-PAM by streaming current measurement respectively. C-PAM and A-PAM resulted similar charge behaviors by titration of opposite charged materials like K-Polyvinylsufonate or Methylglycol chitosan solution. Although final titer amounts were almost same however, initial charge among linear PAM , branched PAM and Cross linked PAM were distinctively different. As increase branch degree of PAM, initial charge conditions were decreased by their steric effects.

We can easily estimate morphology of PAM by comparison of these charge titration graphs.

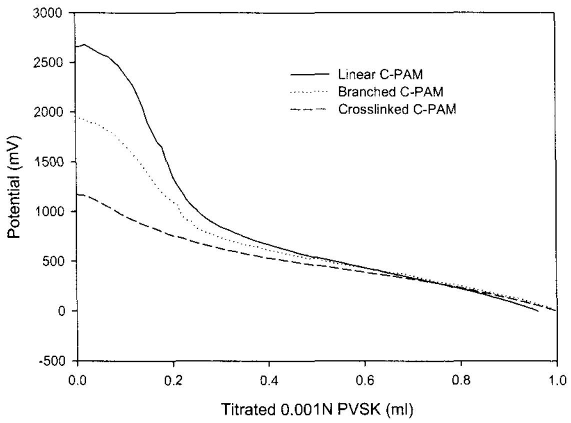

Fig. 3 Charge titration of C-PAM

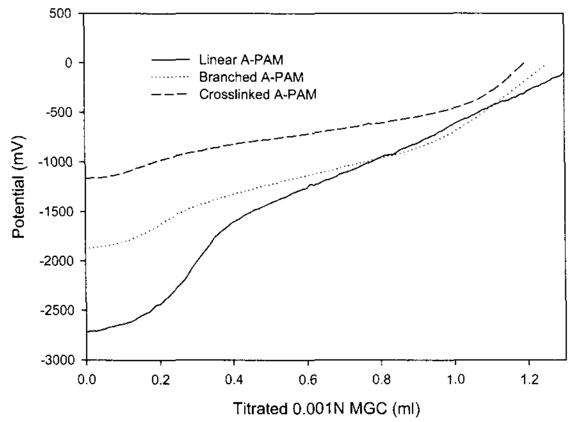

Fig. 4 Charge titration of A-PAM

3.2. Retention, drainage and formation test

3.2.1 Dual system of C-PAM and A-PAM

Fig.5 to Fig.7 shows the retention, drainage and formation to modify morphology of C-PAM. At the result, retention and drainage of linear form of C-PAM were better than cross-linked form of it. However the formation result was observed reversely. Linear form of C-PAM to be considered to tangle and bend easily compare to cross-linked form of it showed easy to flocculate among pulp, filler and polymer to make big and low dense flocs which affected positive effect on good retention and drainage properties. On the other hand, cross-linked C-PAM to have rigid network type structure showed difficult to flocculate among pulp, filler and polymer however, this type of polymer could make more dense and tiny flocs which affected positive characteristics of better formation. In this reason, finding optimal morphology of C-PAM is very important to develope retention polymers. Fig.8 to Fig.10 shows the retention, drainage and formation to modify morphology of A-PAM. Test efficiency was lower than that of C-PAM but, tendency was similar to the result of C-PAM. Therefore, We chose branched morphology of C-PAM and A-PAM as a optimal condition of retention aids to compensate defects of the each morphology.

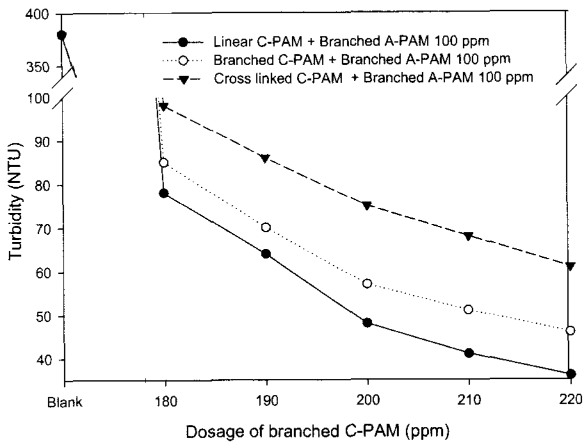

Fig. 5 Retention of dual system by different morphology of C-PAM

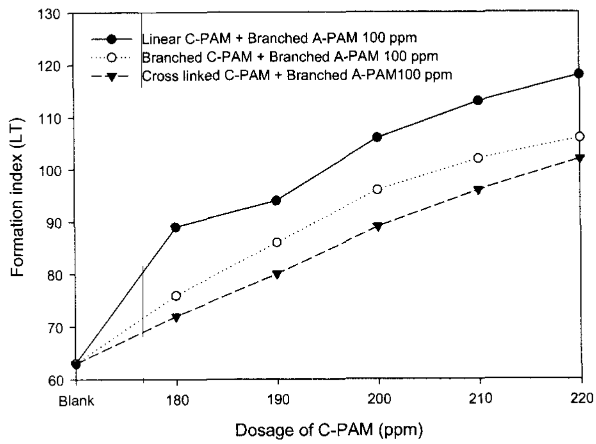

Fig. 6 Formation of dual system by different morphology of C-PAM

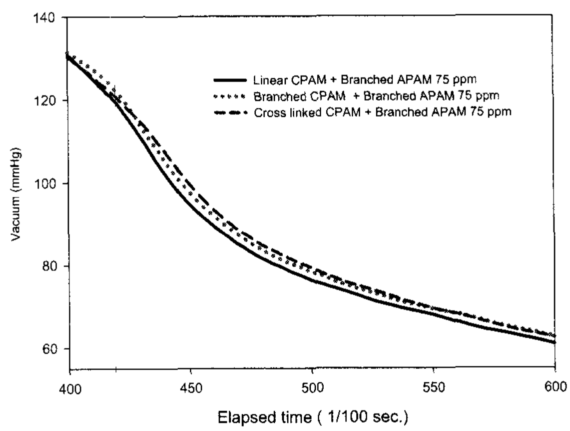

Fig. 7 Drainage of dual system by different morphology of C-PAM

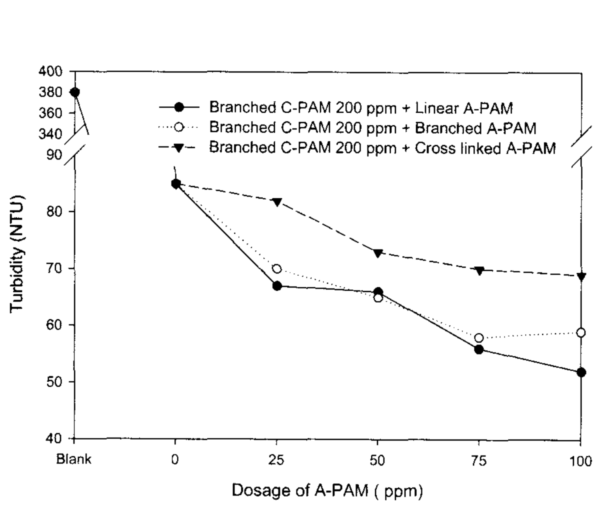

Fig. 8 Retention of dual system by different morphology of A-PAM

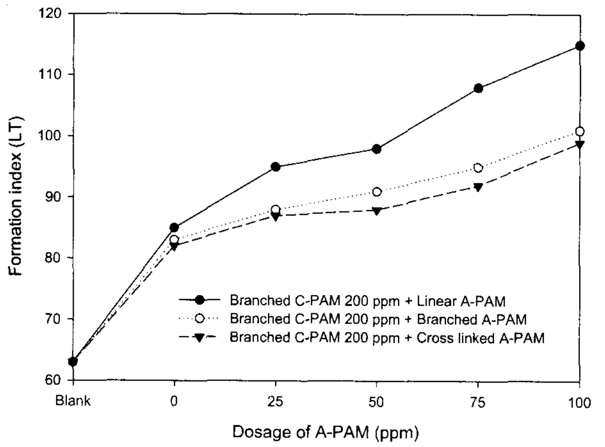

Fig. 9 Formation of dual system by different morphology of A-PAM

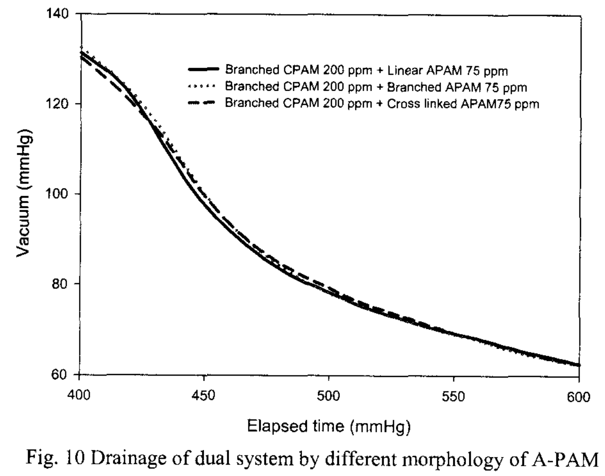

Fig. 10 Drainage of dual system by different morphology of A-PAM

3.2.2 Microparticle system of C-PAM and Inorganic particles like bentonite and silica

Fig.11 to Fig.13 shows the retention, drainage and formation using bentonite and silica. Bentonite was pre-treated before the test by the shear force of 1 hour at the 2,000 rpm and 4 hour of retention time for swelling. Silica was used with no pre-treatment. To compare retention result, performance of silica was better than bentonite at the low dosage condition, however bentonite was better than silica at the high dosage condition. To compare drainage result, performance of bentonite was better than silica. On the other hand, silica was better than bentonite to compare formation result. These results might be originated from differences of ionicity and morphology between silica and bentonite. bentonite was the disk type morphology and amphoteric characteristics and silica had the spherical type morphology and anionic characteristics. Therefore, it might be selected to consider paper mill condition and purpose of using chemicals. When paper mill needs more productivity, bentonite might be selected for better drainage and when paper mill needs more paper quality, silica might be selected for better formation.

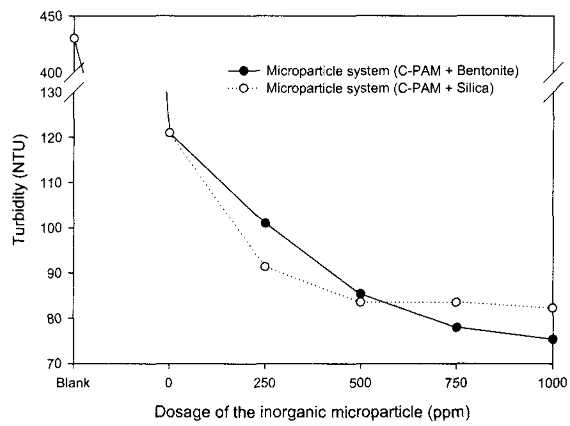

Fig. 11 Retention of microparticle system

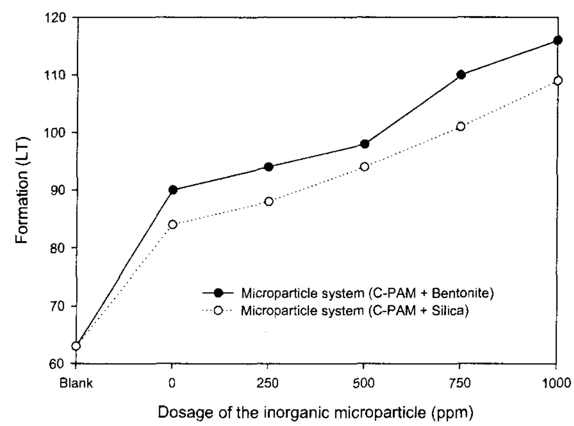

Fig. 12 Formation of microparticle system

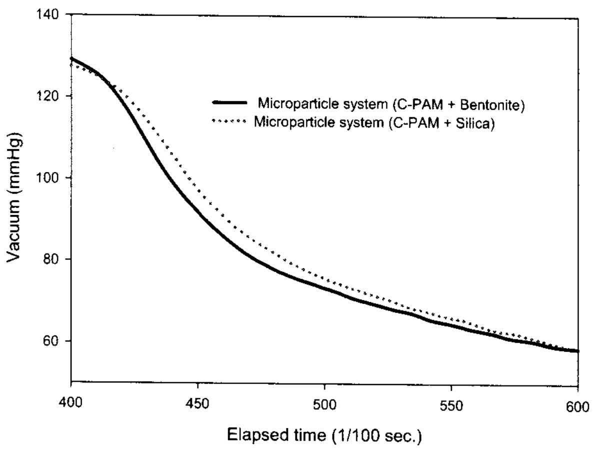

Fig. 13 Drainage of microparticle system

3.2.3 Triple system of C-PAM, A-PAM and Inorganic particles like bentonite or silica

To make up for the weak points of the inorganic microparticle system and dual polymer system, A-PAM and inorganic microparticles were added at the same time after C-PAM injection. In case of retention and drainage properties, multiple system of C-PAM, bentonite and A-PAM was slightly better than multiple system of C-PAM, silica and A-PAM. In case of formation property, multiple system of C-PAM, silica and A-PAM was considerably better than multiple system of C-PAM, bentonite and A-PAM. These result could be explained by synergy effect of inorganic microparticle and branched A-PAM because of making up defects of each materials.

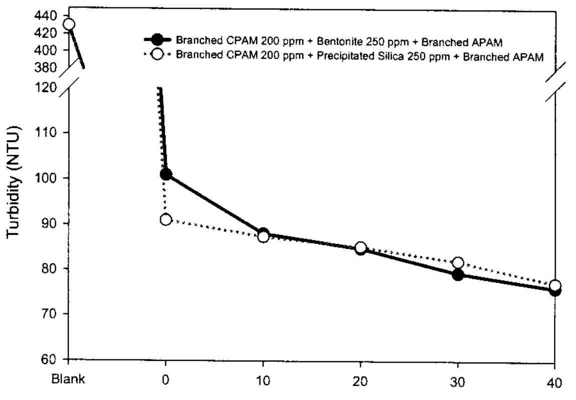

Fig. 14 Retention of triple system

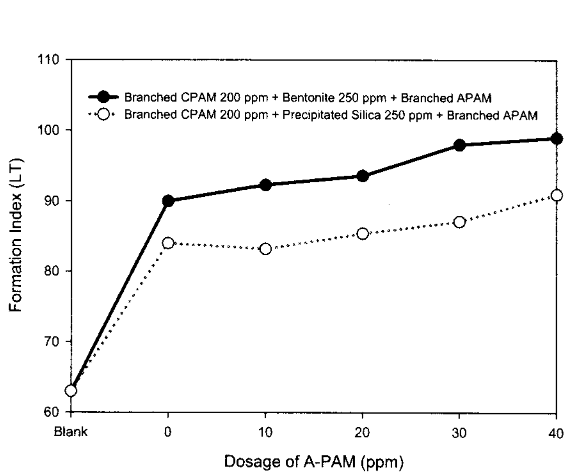

Fig. 15 Formation of triple system

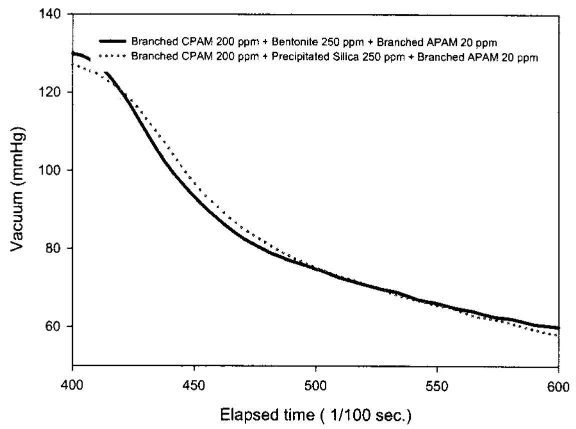

Fig. 16 Drainage of triple system

3.2.4 Comparison of each retention system

Comparing test results of dual polymer system and inorganic microparticle system, dual polymer system was good at retention and formation properties and inorganic particle system observed good at drainage property. Comparing both of inorganic microparticle systems, bentonite was good at drainage property and silica system was good at formation property. we found triple retention system of C-PAM, inorganic microparticle and A-PAM was more suitable than traditional dual polymer system or inorganic microparticle system. Because the consumption of inorganic micropartilce of triple retention system was 25% of traditional inorganic microparticle system and the consumption of A-PAM of triple retention system was 40% of dual system. Therefore, it was estimated to have possibility to reduce total chemical cost and we could choose one from C-PAM, bentonite and A-PAM system or C-PAM, silica and A-PAM system to consider paper mill condition and purpose of using retention aids.

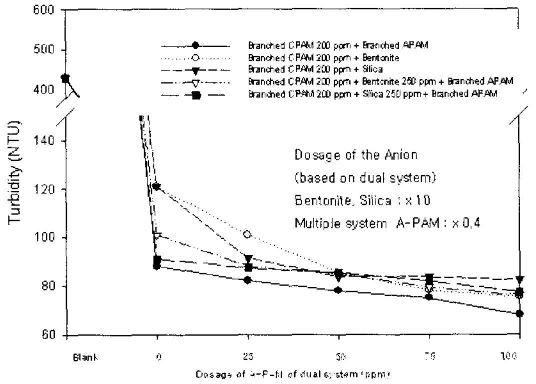

Fig. 17 Comparison of retention of each retention system

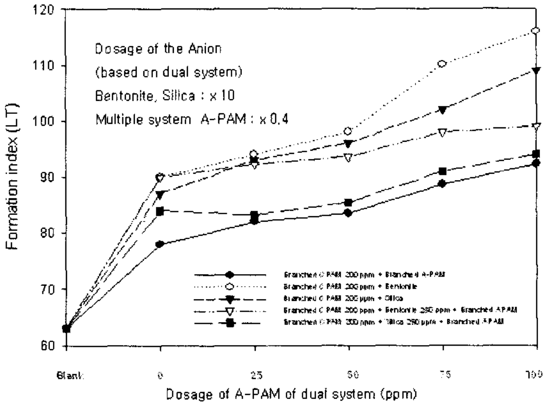

Fig. 18 Comparison of formation of each retention system

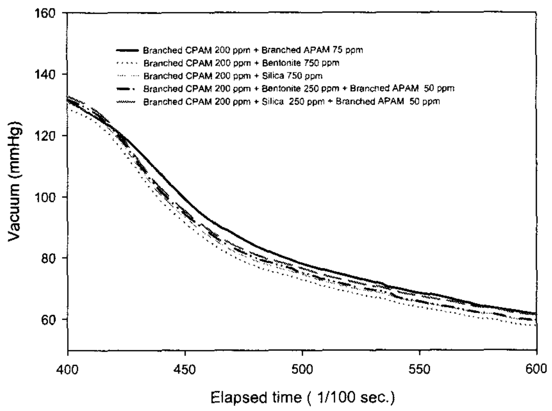

Fig. 19 Comparison of drainage of each retention system

4. CONCLUSIONS

First of all, branch degree of PAM can be estimated by comparison of viscosity profile or charge titration phenomena. Second, optimal morphology of C-PAM and A-PAM was found branched form compare to linear or cross-linked type because this type of C-PAM and A-PAM can compensate weak points of linear type and cross linked type C-PAM and A-PAM. Finally, selected branched C-PAM and A-PAM were applied with bentonite or silica at the same time to find optimal triple retention system. Triple retention system of C-PAM, inorganic microparticle and A-PAM improved drainage property of weak point of dual polymer system and improved formation property of weak point of microparticle system and also open possibility to reduce total chemical cost.

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